ESRF	**Experiment title:** Exploring dimensions of self-assembly of magnetic core-shell particles	**Experiment number**: 26-02/644
Beamline: BM-26B	**Date of experiment**: from: 20-04-2013 to: 25-02-2013	**Date of report**:
Shifts: 11	**Local contact(s)**: Dr. Giuseppe Portale	*Received at ESRF:*

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Report:

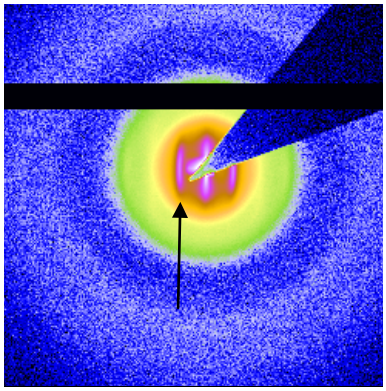
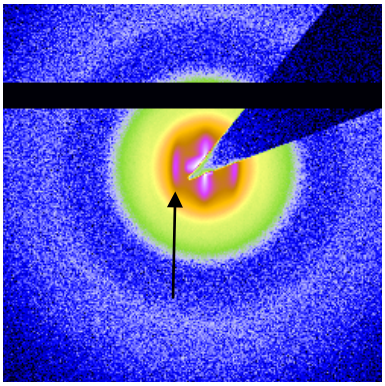
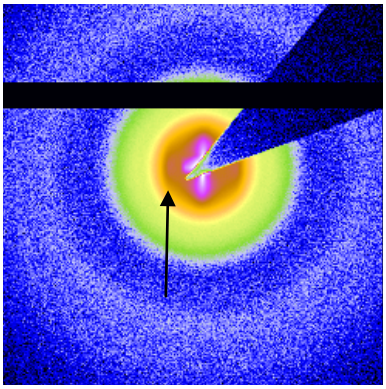
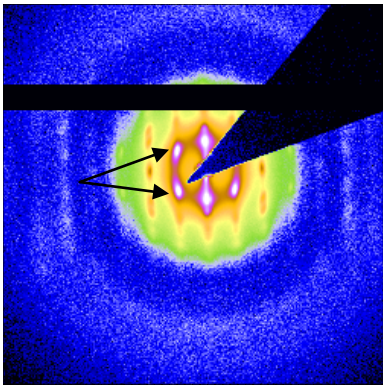
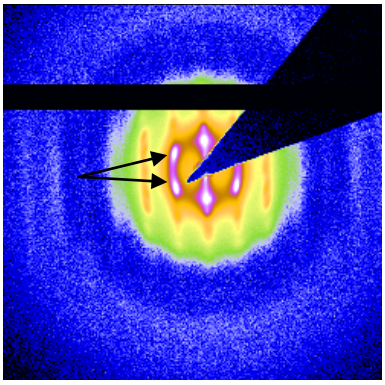
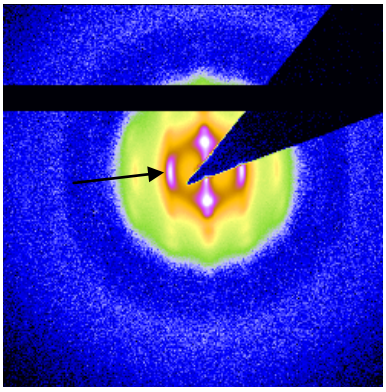
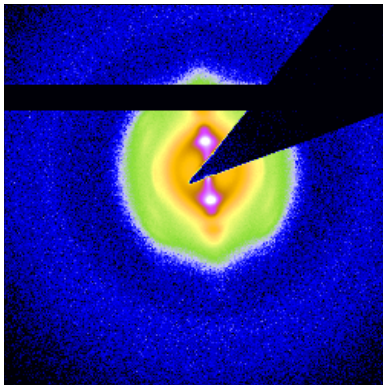
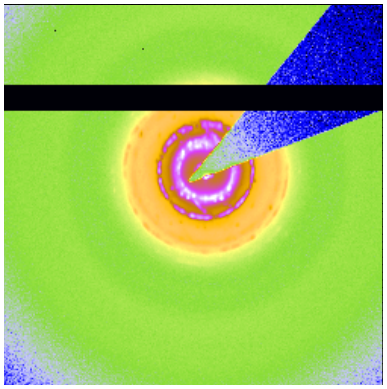
This experiment was devoted to the studies of the self-organization of magnetic core-sheel particles in suspensions placed in magnetic field. The main programme of this experiment was completed in time since no serious technical problems arose. The photon energy was 12 keV (wavelength 1.033 A) except for the last day, when it was changed for 10 keV (wavelength 1.24 A).

For this experiment we have brought a magnet designed by Janne-Mieke Meijer and fabricated in the mechanical workshop of Utrecht University specifically for synchrotron experiments of this type. The magnet allows taking scattering patterns for angles of rotation around the vertical axis up to ±70 degrees (at 0 degree rotation angle the magnetic field is normal to the x-ray beam). In this way we were able to explore most of the 3D reciprocal space of the samples in the magnetic field. The magnetic field is generated by a set of permanent magnets and can be varied between 12 mT (at maximum pole separation) up to about 500 mT at pole separation of 6.5 mm (limited by the capillary size together with the sealing glue).

Some of the collected data is illustrated in the following. In this experiment we have managed to catch up clear signs of the formation of 1D chains as illustrated in patterns 1a-1c. These signs were not sufficiently clear in our previous work [1]. At normal incidence one can see a set of vertical stripes of scattering separated by the inverse spacing along the chain given by the particle size. Upon sample rotation (together with the magnet) one can see that the stripes (marked by arrows) move away in the horizontal direction. These features are characteristic for 1D chains aligned along the magnetic field.

Patterns 2a-2d illustrate examples from the rotation series in a higher field of H=26.5 mT. One can, for example, see that the features marked by arrows come closer together at the rotation angle of 20 degrees, merge at 40 degrees and disappear at larger rotation angles. This indicates that these features form a ring in the 3D reciprocal space. The data are consistent with the formation of 2D sheets, which can rotate around the field direction.

Finally, pattern 3 presents a diffraction pattern measured in the sediment, which was left unperturbed without application of the magnetic field. This pattern is characteristic for a powder of colloidal crystals with random-stacking hexagonal close-packed (rhcp) structure [2].

		
Pattern 1a: gonio=0, H=12 mT	Pattern 1b: gonio=30, H=12mT	Pattern 1c: gonio=45, H=12mT
		
pattern 2a: gonio=0, H=26.5 mT	pattern 2b: gonio=20, H=26.5 mT	pattern 2c: gonio=40, H=26.5 mT
		
pattern 2d: gonio=60, H=26.5 mT	Pattern 3: Powder diffraction from self-organised crystals without magnetic field.	

In addition, preliminary measurements are performed in suspensions of ellipsoidal core-shell particles. Here we have seen indications of the particle alignment in the magnetic field but no clear signs of long-range ordering are observed. The data is to be analysed in more detail. A follow up experiment on this system depends on the outcome of the detailed data analysis and further progress with the sample development.

References

[1] Malik, V.; Petukhov, A.V.; He, L.; Yin, Y.; Schmidt, M.; Langmuir, **28**, 14777-14783 (2012).

[2] Petukhov A.V. , Dolbnya I.P. , Aarts D.G.A.L. , Vroege G.J. , Lekkerkerker H.N.W.; Phys. Rev. Lett. **90**, 028304 (2003).